

Techniques development for the reestablishment of the long-spined sea urchin, *Diadema antillarum*, on two small patch reefs in the upper Florida Keys

Second Interim Report, March 6, 2002.

Ken Nedimyer, Principal Investigator
Martin A. Moe Jr., Associate Investigator

We are now a little past the mid point of the project, 6 months after the first translocation of *Diadema* urchins onto the experimental reefs and about 5 months after the submission of the first interim report dated September 17, 2001. This second interim report will not include the reef and technique descriptions reported in the first interim report. Please refer to the 1st interim report for information on the initial phase of the project.

Summary of results

The first interim report covered the selection and mapping of the experimental and control reefs and the initial collection, establishment, and translocation of the first group of *Diadema* sea urchins, 200 to reef # 1 and 85 to reef # 2. Since this initial collection and survival count in early September of 2001, there have been eight additional collections of *Diadema* urchins from the rubble zones on the shallow tops of Pickles and Conch reefs with translocation of an additional 408 urchins (231 to reef #1 and 177 to reef #2) to the experimental reefs. These collections and translocations took place between late September to mid December 2001. Since the first interim report in mid September, Ken Nedimyer has made five counts of surviving *Diadema*. The last count, accomplished February 2, 2002 recorded 202 urchins on reef # 1 (total translocated 431) and 122 urchins on reef # 2 (total translocated 262). Interestingly, the survival rate for *Diadema* on both reefs at this last count was 47%. The urchins that have survived on reef #1 at the last count were at a concentration of about 2 per square meter and those on reef #2 were at a concentration of about 1.3 per square meter.

The *Diadema* urchins that have survived on both reefs have grown into young adults and some spawning of the urchins was observed during the collection and translocation that was done in mid December 2001.

Table 1 is a summary of all collection data of urchins from Pickles and Conch reef. Note that Table 1 reports collection of 741 *Diadema* urchins and Table 2 reports 693 urchins translocated to the experimental reefs. The 48 urchins that were not released on the experimental reefs, from the 75 urchins collected on September 19, 2002, were used in a study with Dr. Alina Szmant comparing survival of wild and tank reared *Diadema* juveniles. This study was conducted by Ken Nedimyer at Dr. Szmant's request on a small reef area near the experimental reefs. The last column in Table 1 reports the effort expended in the collection of the 741 *Diadema* urchins in terms of hours of time spent in collection of the urchins. This was included to provide some insight into the effort required to collect the urchins from the shallow, 6 to 10 feet depths of the rubble zones on

the reefs. A collector dives with SCUBA gear and roams the rubble zone with a large hand net and a short aluminum or fiberglass rod. Urchins are usually seen around and at the edges of the larger rocks and rock formations and under large flat rocks that must be tipped up to see under them. When an urchin is located, the 12" rod is used to flip the urchin up off the bottom and it is then caught in the hand net. When the hand net is full with urchins, the collector returns to the boat and places the catch in a holding tank aboard the boat. It is very helpful to have a person aboard the boat to take the net from the collector and place the urchins in the tanks. Usually, two collectors worked the bottom and one additional person helped handle the urchins. The effort reported in Table 1 consists of only of the total collector hours expended during each collection trip (one, two, or three collectors). The total collection hours expended to take the 741 urchins was 30, and this resulted in an average yield of 25 urchins per collection hour.

Table 2 is a summary of the release (translocation) data for urchins on both experimental reefs, counts of urchins observed at various times, and survival rates at each count. Note that the survival rates are a product of the counts of live *Diadema* observed on each reef on a specific date. The survival rate is thus an estimated percentage survival based on the number of urchins observed on a particular visit to each reef. It is quite possible that a number of urchins at each count are so hidden in the reef structure that they are not observed and not counted on that visit, thus the percentage survival reported represents the minimum possible survival rate estimate. Reef #1 is more rugged with high coral formations than reef #2 thus the possibility of not finding all urchins present is considerably greater for reef # 1.

At this point in the project we feel that it is possible to claim that we have successfully established a surviving population of *Diadema antillarum* on two small patch reefs in the Upper Florida Keys by translocation of juveniles from shallow rubble areas where they would not have survived the winter storms. The National Undersea Research Center (NURC) will document changes in algal and coral cover, compared to their ecological assessment at the beginning of the project last year. Also, the structure and growth of the *Diadema* populations on these reefs will be documented at intervals during the remainder of the project.

Discussion

Initially, we hoped to achieve a concentration of about 4 *Diadema* urchins per square meter on each reef, which was an abundance level often reported for urchins prior to the plague of 1983-4. Mortality of the urchins, about 53%, over the first six months of the project prevented us from achieving this population level throughout the first half of the project. However, the concentration of urchins on the experimental reefs of about 2 per after the first 6 months of the project appear to be well within the population density required to reduce the abundance of algal growth on these reefs. The population density in numbers per square meter is based on the entire footprint of the patch reef. The urchins, however, are concentrated in specific areas of the reefs and their numbers per sq. m are higher within the more rugged areas of the reef and very much lower in areas with

sparse coral and rock formations. Movement, internal population, densities, growth and reproductive condition will be addressed in the final report.

Survival rates were high, 80 to 90 percent, during the first month after initial translocation of urchins to the experimental reefs. The Upper Florida Keys were brushed by two fall hurricanes, Gabrielle on September 14, 2001, and Michelle on November 4, 2001. The Upper Keys areas experienced sustained winds of about 25 to 30 knots and gusts of about 40 knots in both storms. There was evidence of damage from storm surges on the experimental reefs after both storms. The surge from Hurricane Michelle in early November, however, seemed to effect survival rates since they dropped to 45 and 50 percent after this storm. Although mortality rates seemed to remain consistent at about 45 percent on both reefs during the fall and winter months after Hurricane Michelle, mortality on reef # 1 was apparently a bit greater since 67 additional urchins were translocated to reef #1 during December with only 24 urchins translocated to reef #2 during that same period. Thus reef #1 had 43 more urchins added to its population in December than reef #2. Survival rates on both reefs, however, have held constant at 45 to 47 percent over the winter months of December and January.

It is quite possible that one of the major reasons that recovery of *Diadema* populations on Florida reefs has not occurred is because settlement of late larvae and/or early juveniles is greatly enhanced by the presence of dense populations of adults. Considerable numbers of adult urchins may prepare the substrate by grazing algal growth down to clean limestone surfaces, thus providing a surface that encourages settlement and survival of juvenile urchins. The tumbled clean rock surfaces of the rubble zones at Pickles and Conch reefs may be the reason that juveniles settle here during the late summer months.

Also, the presence of adults and their long, protective spines may provide important shelter for the juveniles during the period that they are most vulnerable to predation. It is also possible that adult urchins may emit chemical cues, pheromones that attract and stimulate settlement and metamorphosis of the late larvae to a specific area. And when the almost microscopic *Diadema* post larvae do settle onto a substrate, the presence of equally small predators, crabs and other crustaceans and mollusks, that inhabit dense algae growths may well prevent survival of all but a very few newly settled urchins.

These possibilities have not been researched experimentally for this species and they are simply speculation at this time. However, where limited concentrations of *Diadema* urchins have been observed in certain small areas of the Keys and the Caribbean, they occur in numbers only in strongly delimited patches. This provides empirical evidence that the presence of adults somehow attracts or enables the settlement of juvenile urchins. Because, if settlement and/or survival of *Diadema* urchins was not somehow dependent or enhanced by populations of adults, it seems reasonable that widespread survival of scattered individual *Diadema* would occur on reefs throughout the region.

It will be easy to observe any recruitment of new juveniles into these experimental areas since the translocated urchins have now grown into adults and small juveniles will be easily observed if they settle onto the experimental reefs. We will carefully count and

record the appearance of any small juveniles that appear on these reefs during the remainder of this project.

Appendix 1. Tables 1 and 2.

Appendix 2. Photos of collection procedures.

Appendix 3. Informal dive log of Martin A. Moe, Jr.

Appendix 1

Table 1. Collection data for juvenile *Diadema antillarum* at Pickles and Conch reefs.

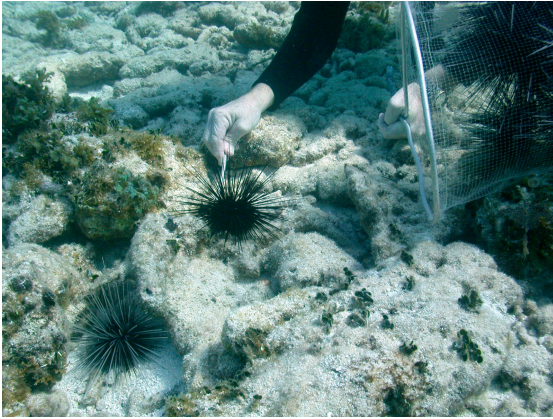
Date 2001	Conch	Pickles	small 1 – 2.5 cm	medium 2.6 – 4.0 cm	large 4.5 – 6+ cm	effort in collector hours
09/04		162	43	102	17	6.0 hrs
09/05		123	23	93	7	6.0 hrs
09/17	11			11		0.5 hrs
09/19	75		58	13	4	2.0 hrs
09/21	105		32	33	40	6.0 hrs
09/26	78		53	14	11	1.5 hrs
10/05	41		15	5	21	1.5 hrs
10/24		55	22	14	19	2.0 hrs
12/14	17		1	6	10	0.5 hrs
12/20	74		2	15	57	4.0 hrs
Totals	401	340	249	306	186	30.0 hrs

Table 2. Translocation and survival data of *Diadema antillarum* on two experimental reefs.

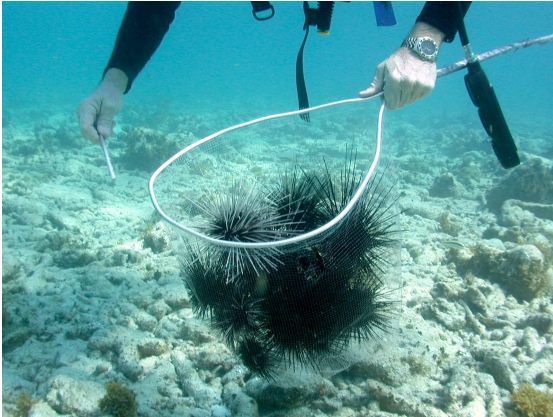
Date	Experimental Reef # 1				Experimental Reef # 2			
	total released before count	total count	% survival	# released this date (after count)	total released before count	total count	% survival	# released this date (after count)
09/04,5				200				85
09/08	200	160	80		85	79	93	
09/17				11				
09/19	211	172	82		85	79	93	27
09/21								105
09/26				78				
10/05				41				
10/24				34	238*	155*	65*	21
11/09	364	161	44		238	118	50	
12/14				17				
12/20	381	175	46	50	238	106	45	24
02/26	431	202	47		262	122	47	
Totals				431				262

*this count included the 21 released on this date

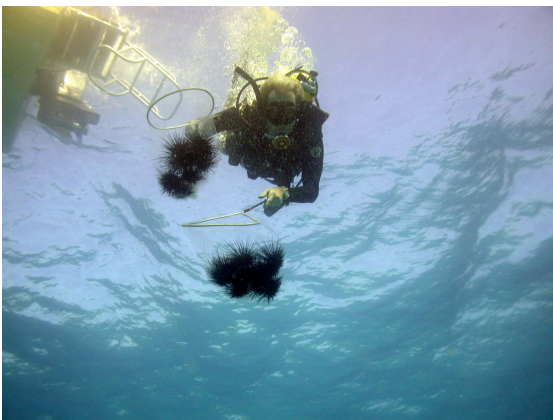
Appendix 2



Ken eases an urchin into the collecting net.



A net full of urchins is returned to the boat.



Transporting the urchins, 10 in each net, from the boat down to the experimental reefs.

Appendix 3

September 21, 2001

Ken, Brian Keller, Sanctuary Science Coordinator, Joanne Delaney, Sanctuary Research Interpreter, and I made a trip to collect and translocate additional urchins to the experimental reefs of the Diadema project. We left the dock at about 10:00 AM and returned at about 2:00 PM. We first went to the shallow rubble zone of Conch Key and spent about two hours collecting urchins. We collected about 100 urchins, Ken has the exact number collected, the size ranges, and the placement of the urchins on Experimental reef # 2 (all the urchins were placed on this reef). Most of the urchins were in the medium to large category, with, as I recall, about 25 in the small category. Note that these size ranges, small, medium and large, pertain to juvenile urchins, not to the full range of size that a population of mature Diadema urchins would include. The largest of these juveniles, had a test size that in my estimation was no larger than a baseball, and most were considerably smaller than this. The urchins on this site, Conch Key, as compared to the collections on Pickles Reef, appeared to range a bit larger in size.

After collection of the urchins, we moved over to the project site and anchored near Experimental Reef # 2. The two experimental reefs are so close, separated by only about 40 feet of grass, that both reefs are easily worked from any nearby point of anchor. We discussed placement of the urchins before the translocation dive, and decided to place them all on Experimental reef # 2. The density of urchins on Experimental reef # 1 at this point was about 2 per sq. m and that of Exp. Reef # 2 was only 1 per sq. m. Placing all 100 urchins on Reef #2 would bring both Reefs to a density of about 2 per sq. m.

Ken had visited the site last Wednesday, Sept. 19, and made a complete count so we did not take the time to make another count on this trip. I don't have the exact figures on Ken's last count yet, but as I recall from the numbers he told me, his count was a little higher on the Sept. 19 count than the count of Sept. 8. Which indicates that the urchins are acclimating well to the new conditions on the patch reef and mortality among the translocated urchins is very low if any has occurred at all. Joanne stayed in the boat while Ken, Brian and I made the translocation dive. Ken directed the placement of the urchins based on the maps and previous placements of urchins. Joanne sorted the urchins by size and placed them in the nets. I ferried the nets of urchins down to the reefs and Ken and I placed them in the appropriate reef structures, and as before, they immediately "scurried" into the nearby reef structures. Brian watched us move the urchins and examined the reefs and took notes on his observations during the dive.

I took photographs and examined the reefs closely at the end of the urchin translocation. I saw no sign of urchin mortality and a lot of what I think is evidence of urchin activity on the reefs. The large urchins that we translocated were readily observed all over the both reefs and the small ones were hidden in the reef structures and required careful observation and scrutiny under and within the reef structure to find them. Eppie, the 3 foot red grouper with the scratches on her head and left operculum, followed us around as

usual and observed us carefully as we worked Reef #1. She has been on that reef in the same area since the first visit.

Ken is also helping Alina Szmant with her study of *Diadema* urchins, particularly the introduction and monitoring of small tank reared *Diadema* in natural reef areas. There has been, as I understand it, high mortality in the small tank reared urchins placed in natural areas and Ken and Alina have set up a small experiment in an area separate from, but near by our project sites. Ken has established four small areas on a nearby low profile reef and placed a small number of tank reared urchins on two of these areas and about the same number of wild urchins (around 5 to 10 urchins on each site). We visited this area at the end of the dive to count the tank reared and the wild urchins. Ken has the numbers on this count. It appeared to me (empirical observation) that the wild urchins were more numerous, apparently experiencing little mortality; while the tank reared urchins were considerably fewer in number. The tank reared urchins were of different appearance, shorter, fewer spines and darker in color, than the wild urchins. The tank reared urchins also seemed less integrated into the reef structure and were more easily observed than the wild urchins. Although some were in niches in the reef, several were found in rather open areas, sand pockets, of the reef structures.

Brian and Joanne both seemed impressed with the detail, documentation, and results of the project at this point. At the end of the trip, Brian, his wife, Fiona, Ken and I had a late lunch and discussed many things pertaining to the project. In particular, I wanted to set a reasonable and doable density figure that we should aim for on the Experimental reefs. Complexity of reef structure is a consideration since a rugged complex structure should support more urchins a low hard bottom. It is also a given that over time the urchins themselves will move to areas that offer the best shelter and sources of food. We decided that a level of about 4 *Diadema* per sq. m would provide a close enough density to approximate pre plague densities on these reefs. This is a “guessestimate”, of course, and there are many, many questions that have no answer at this point in this regard, but we feel that this figure, 4 per sq m, about double the present density on the Experimental reefs, will give us a strong population that will produce significant results within the time frame of the project. We should be able to accomplish this with two or three more translocations within the next few weeks.

December 6, 2001

I have not visited the *Diadema* sites since the last record on the log. Ken has visited the sites to count and/or to make additions to the translocated *Diadema* urchins on 9/17, 9/19, 10/5, 10/24, and 11/9. We are giving a presentation to the Sanctuary Advisory Council on 12/11 so I have made a concise analysis of the data to date. On Reef #1, we released a total of 286 *Diadema* and at the last count on 11/9 Ken was able to find 161 *Diadema*, a known survival rate of 56%. We released a total of 238 *Diadema* on Reef # 2 and on 11/9 Ken was able to find 118, a known survival rate of 50%.

December 13, 2001

Ken picked up 17 more *Diadema* on Conch reef on this date and transferred them to Experimental Reef # 1 on this date. His note is below. I did not go along on this trip, but I hope to get out with Ken again before the end of the year.

"While diving at conch reef today I picked up 17 urchins that I took to site # 1. There weren't many left in the shallows at conch, but there were a few scattered in deeper water. I only saw one instance where there was two close together, the rest were separated by 15 to 20+ feet. I didn't spend too much time actually collecting them and if I get a nice day I might spend a whole dive and see if I can't get 50 to 100. The site was cloudy and there was lots of dead turtle grass sloshing around, but the urchins looked good. I found them everywhere I expected to, and on some of the sites where I had released only small guys they were still there and had grown. the smallest urchin I saw clearly was about 2-3cm, most were 4cm or bigger. they looked good. At Conch I only found one that was less than 3cm, the rest were 4 to 6cm. Ken"

December 19, 2001

The day was beautiful. One of these rare days between cold fronts when the winds were light (although they picked up considerably from the NE in the afternoon) and the water was clear and cool. Ken decided to spend the day on the *Diadema* project and I went along to help. We left the dock at about 10:30 AM and returned at 4:30 PM.

We went to Conch Reef and anchored in the rubble zone but on the offshore side where the water was about 8 to 10 feet deep. Some of the formations were a little larger and more solid than the smaller more loose rubble a few yards to the west. This area is also subject to extensive agitation and washing during the winter storms. *Diadema* urchins were more abundant than I expected. We were able to collect 74 in about one and half hours and they were all rather large, golf ball to baseball size. There were no small urchins in the marble size that were relatively abundant in September. I pondered this for a while and then realized that these were the small urchins of September that had survived (so far) and had grown up. Notably, I saw no large, mature urchins of an age greater than perhaps 6 months or so. *Diadema* urchins live for an estimated 5 to 8 years so if they could survive in this environment over the winters, there should be some large mature urchins in this location. Mostly they were scattered singly or in twos here and there on the larger rubble formations. Only in one area did I see a number of them in one relatively small location, 8 fairly large individuals. I took two and left the rest to take their chances at survival. As I brought the net full of urchins to the boat, I noticed that the water looked a little funny around the net but I was too busy with nets, fins, tanks, waves and swim ladders to think much about it. Later Ken asked me if I had seen the urchins spawning and I realized that was why the water "looked funny" around the net. This is good news for it they spawn that early on the rubble zone, they should also spawn on the experimental reefs. We then took off for the project site and got there I think about 1:00 PM.

We anchored up between Experimental Reefs 1 and 2. The first order of business was to do a complete count of the surviving urchins on these two experimental reefs before we added the recently collected urchins to the reefs. Ken accomplished this while I took

photos and hunted for urchins to see how they were growing and surviving and also to see if I could find any evidence of their grazing activity on the reefs. Again, no matter how hard I looked, I could not find any small, less than perhaps 4 cm test diameter, urchins. There were many large urchins present in every location that one would expect to see urchins. They were under coral heads, between rocks, grouped in crevices and holes in rock formations, all over the reef. Again it was obvious that the small urchins had grown up. Ken has the counts on the numbers and will add them up soon and we will have an estimate on numbers that have survived so far. There was some evidence of predation, mostly on Reef # 2. Ken pointed out a couple of areas where there was an accumulation of urchin spines that seemed to indicate predation, but I found no pieces of urchin tests in these or in other areas.

I looked closely to see if I could find evidence of grazing by the urchins on the rocks. It looked like there had been a lot of macro algae removal as the rocks appeared relatively clean but I could not discern actual scrapes and cleaning down to a bare rock surface. *Halimeda* (perhaps discoidea) was the most prominent macro algae and the “tufts” of this alga at the point of attachment were clean and separate with little build up of sediment. These tufts were also scattered over the rocks and not concentrated in dense growths as I have seen it before. It was not until I examined and compared the rock at the control reefs that I was struck by the apparent difference in algal growth. The control reefs had extensive growths of *Sargassum* spp. and to a lesser extent, *Dictyota* spp. as well as *Halimeda* spp, which I had not seen to that extent on the experimental reefs. I think the urchins have removed much of the macro algae growth on the experimental reefs, but my observations are casual and not measured in any way. The survey by NURC will tell the tale. But logically, if they are still there in considerable numbers and have grown well, they must be eating something, and with so many urchins on the reefs, it should be evident. Next time I visit the site I will spend more time in comparison of the macro algae cover on the reefs.

After the counts were complete we transported the collected urchins down to the reefs and released them. As before, there were no mortalities and all the urchins rapidly moved into cover on the reefs. We released 50 on reef #1 and 24 on reef #2. Kelly, Ken’s daughter helped us in the collection and distribution of the urchins. It is a big help to have someone on the boat to put the urchins in the nets and hand them to the diver that transports them down to the reef.

Control reef #4 is located a bit distant, 100 yards maybe, from the other three reefs. We finished the day by going over to this reef and taking photos and establishing 3 photo quadrats and taking photos of this area. This reef was chosen as one of the control reefs because the coral formations were about the same size as the formations on Experimental reef # 1 and it would function as a good comparison to this reef. However we did find 5 good size, not fully mature but fairly large, urchins on one formation on this reef. As I recall, we did notice one or two urchins on this reef when we first examined it. This will have to be taken into account when the final analysis is made.

We then pulled anchor and returned to the dock at 4:30 PM.